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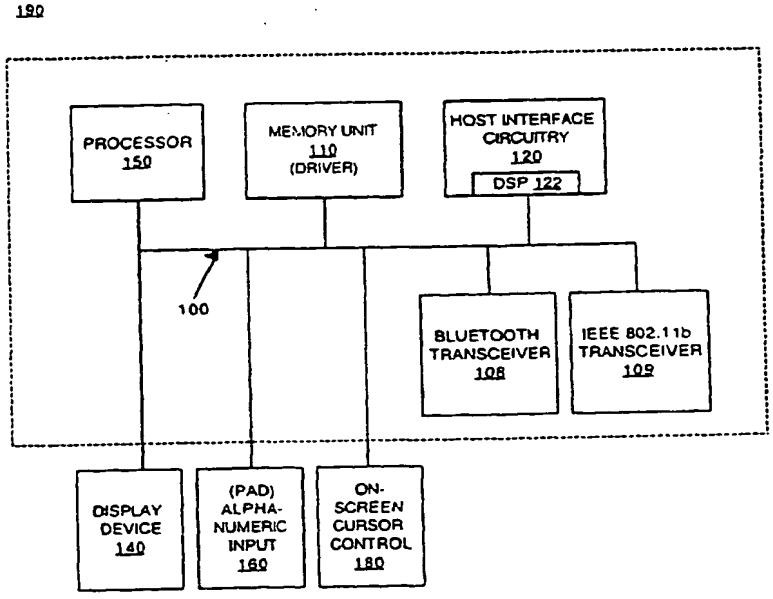


(57) Abstract: A single system (and method thereof) that combines the functionality of different wireless connectivity technologies (e.g., the Bluetooth and IEEE802.11b wireless technologies). Common systems can be shared, such as a common 2.4 GHz radio frequency (RF) antenna control, RF/IF system, and demodulator; common baseband systems such as a common direct sequence spread/despread engine with frequency hopping control and RF power controls:medium access controllers; and software stacks. Logic implemented in hardware, software and/or firmware is used to arbitrate between the differentwireless technologies.

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# DEVICE AND METHOD COMBINING DIFFERENT WIRELESS CONNECTIVITY TECHNOLOGIES

## CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims Convention priority and priority under 35 U.S.C. § 119(e) to U.S. Patent Application No. 60/274,521, filed March 8, 2001, entitled "DEVICE AND METHOD COMBINING DIFFERENT WIRELESS CONNECTIVITY TECHNOLOGIES," the contents of which are hereby expressly incorporated in their entirety by this reference. This application also claims Convention priority and is a U.S. continuation of U.S. Patent Application No. _____, filed March 7, 2002, entitled "DEVICE AND METHOD COMBINING DIFFERENT WIRELESS CONNECTIVITY TECHNOLOGIES," the contents of which are hereby expressly incorporated by this reference.

## TECHNICAL FIELD

The present invention relates to devices communicatively coupled using wireless links. In particular, the present invention pertains to a device combining different wireless connectivity technologies, and a method for arbitrating between them.

## BACKGROUND ART

Computer systems and other types of consumer electronic devices are commonly linked to each other and to peripheral devices using a myriad of different types of cables and connectors. As these devices grow in number and variety, their cables and connectors can often become quite cumbersome to work with. Accordingly, efforts are underway to develop technologies allowing hardware (wired) connections between devices to be replaced with wireless ones. Also, as devices become more portable, the mobility of users is greatly enhanced, and therefore wireless connectivity is of increasing importance as it becomes both necessary and desirable to connect devices outside of a conventional wired network.

One wireless connectivity technology is the well known Bluetooth technology. Bluetooth is the code name for a technology specification for small form factor, low-cost, short-range radio links between personal computers (PCs), mobile phones and other devices. Bluetooth is targeted at mobile and business users who need to establish a link, or small network, between their computer, cellular phone and other peripherals. The required and nominal range of Bluetooth is thus set to approximately ten (10) meters. To support other uses, for example the home environment, Bluetooth can be augmented to extend the range to up to 100 meters.

Bluetooth radios operate in the ISM (Industrial, Scientific, Medical) band at 2.4-2.4385 GHz. A spread spectrum frequency hopping transceiver is applied to combat interference and fading. Each packet is transmitted in a different hop frequency. Most of the entire available frequency spectrum is used with 75 hops of one (1) MHz bandwidth.

Another wireless connectivity technology is provided by the well known Institute of Electrical and Electronics Engineers (IEEE) 802.11b standard ("802.11b"). The 802.11b standard provides for wireless data transmission rates that are comparable to those achievable with wired (e.g., Ethernet) systems. The 802.11b standard defines data transmission rates of up to 11 Mbps via radio waves using direct sequence spread spectrum. The 802.11b standard also calls for operation in the 2.4-2.4385 GHz ISM frequency band.

Thus, using either Bluetooth or 802.11b, the many proprietary cables that connect one device to another can be replaced with wireless radio links.

Printers, personal digital assistants (PDAs), notebook, laptop and desktop computer systems, fax machines, keyboards, joysticks and virtually any other device can be part of a Bluetooth or IEEE 802.11b system.

Because Bluetooth and 802.11b exist in the same frequency band, a Bluetooth radio and an 802.11b radio (transceiver) may interfere with each other if they are operating in proximity at the same time (specifically, if one is transmitting and the other is receiving). The interference is reduced if the Bluetooth transceiver and the 802.11b transceiver are spatially separated by a sufficient amount.

However, interference can be a problem when both the Bluetooth and 802.11b technologies need to coexist in a single portable device (such as a laptop or notebook computer system) that, because of its smaller size, does not allow adequate spatial separation between the Bluetooth and 802.11b radios. For example, it may be desirable for a laptop computer system to be able to communicate both with a printer using a Bluetooth connection and with a network of other devices over a wireless LAN (local area network) using 802.11b. Accordingly, the laptop may be equipped with a Bluetooth transceiver and with a 802.11b transceiver. However, adequate spatial separation between the Bluetooth and 802.11b radios may not be achievable within the form factor of the laptop, and as a result the two radios will interfere with each other if they are operating at the same time.

There can be other problems when both Bluetooth and 802.11b need to coexist in a single device, in particular a portable device. Typically, portable devices are battery-powered; supporting both a Bluetooth and a 802.11b

wireless system may tax the capacity of the device's power supply. In addition, locating both wireless systems in a single portable device will consume the limited space available within such a device. Furthermore, Bluetooth and 802.11b have different software and hardware control mechanisms that do not readily coexist with each other. Bluetooth and 802.11b also have different antenna requirements. Therefore, costs can be increased because of the hardware and software needed to support both systems. Also, because of the potential incompatibility between Bluetooth and 802.11b, power and processing time can be wasted in retries and broken connections.

Accordingly, a need exists for a system and/or method that can allow different wireless connectivity technologies to coexist in the same device without interfering with each other. A need also exists for a system and/or method that can satisfy the above need, that can use less power and space, and that can reduce costs. The present invention provides a novel solution to the above needs.

## DISCLOSURE

The present invention provides a system and method that can allow the different wireless connectivity technologies to coexist in the same device without interfering with each other. The present invention also provides a system and method that can use less power and space and that can reduce costs.

In one embodiment, the present invention pertains to a system (and method thereof) that combines the functionality of both Bluetooth and IEEE 802.11b ("802.11b") wireless connectivity technologies in a host device. Embodiments of the present invention share common systems such as a common 2.4 GHz radio frequency (RF) antenna control, RF/IF system, and demodulator; common baseband systems such as a common direct sequence spread/despread engine with frequency hopping control and RF power controls; medium access controllers (MACs); and software stacks. Logic implemented in hardware, software and/or firmware is used to arbitrate between the different wireless technologies.

In one embodiment, the present invention is implemented using separate PCMCIA (Personal Computer Memory Card International Association) cards installed in the host device (e.g., a computer system such as a laptop); one card for one wireless technology, the other card for another wireless technology. In this embodiment, a software driver on the host device provides the logic for arbitrating between the two technologies depending on which is needed by the host device at a particular time.

In another embodiment, functionality for different wireless technologies is combined on a single card or circuit board. In this embodiment, some of the hardware in common is shared between the two systems. The arbitration logic primarily resides on the host device, with a portion of the logic residing on the card/circuit board.

In yet another embodiment, functionality for different wireless technologies is combined on a single card or circuit board using a multi-modal transceiver. In this embodiment, the arbitration logic is primarily or wholly implemented on the card/circuit board (for example, in an application specific integrated circuit or some other type of microprocessor resident on the card or circuit board).

The host device presumes a certain level of connectivity; for example, the host device is configured for printing to a wireless printer via Bluetooth and for sending data to the wireless LAN (local area network) via IEEE 802.11b. In this example, according to the present invention, the data are directed to the appropriate wireless connectivity system (e.g., Bluetooth or 802.11b) which are arbitrated such that only one of the systems is actively transceiving at a time.

In one embodiment, the RF traffic is interleaved using time domain division (TDD), wherein packets (or groups of packets) are sent and/or received in small bursts so that each of the wireless systems appears to the user to be active at the same time. In this embodiment, priority can be given to traffic communicated using one wireless technology, with connections that use another wireless technology being made and broken infrequently as needed. In another embodiment, one of the wireless connectivity systems is made

available to complete a task, and the other system is made unavailable during that time. In yet another embodiment, the RF traffic is interleaved in the frequency domain, wherein the wireless systems are separated in frequency within the same band or channel.

The present invention thus combines different connectivity technologies using a single control system, thereby simplifying the hardware and software requirements for the host system. Also, by removing redundancy in hardware and software, the burden on power systems as well as space requirements and costs can be reduced. In addition, the present invention allows a coherent form of arbitration to take place between different wireless technologies, reducing the power and processing time consumed by retries and broken connections that can result if these systems are operating independently and asynchronously.

These and other objects and advantages of the present invention will become obvious to those of ordinary skill in the art after having read the following detailed description of the preferred embodiments which are illustrated in the various drawing figures.

## BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and form a part of this specification, illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention:

FIGURE 1A is a block diagram showing one embodiment of a device hosting different wireless technologies in accordance with the present invention.

FIGURE 1B is a data flow diagram showing the arrangement of drivers for the device of Figure 1A in accordance with one embodiment of the present invention.

FIGURE 2A is a block diagram showing another embodiment of a device hosting different wireless technologies in accordance with the present invention.

FIGURE 2B is a data flow diagram showing the arrangement of drivers for the device of Figure 2A in accordance with one embodiment of the present invention.

FIGURE 3A is a block diagram showing yet another embodiment of a device hosting different wireless technologies in accordance with the present invention.

FIGURE 3B is a data flow diagram showing the arrangement of drivers for the device of Figure 3A in accordance with one embodiment of the present invention.

FIGURE 4 is a flowchart of the steps in a process for arbitrating between different wireless technologies in accordance with one embodiment of the present invention.

## BEST MODE

Reference will now be made in detail to the preferred embodiments of the invention, examples of which are illustrated in the accompanying drawings. While the invention will be described in conjunction with the preferred embodiments, it will be understood that they are not intended to limit the invention to these embodiments. On the contrary, the invention is intended to cover alternatives, modifications and equivalents, which may be included within the spirit and scope of the invention. Furthermore, in the following detailed description of the present invention, numerous specific details are set forth in order to provide a thorough understanding of the present invention. However, it will be obvious to one of ordinary skill in the art that the present invention may be practiced without these specific details. In other instances, well-known methods, procedures, components, and circuits have not been described in detail so as not to unnecessarily obscure aspects of the present invention.

Some portions of the detailed descriptions which follow are presented in terms of procedures, logic blocks, processing, and other symbolic representations of operations on data bits within a computer memory. These descriptions and representations are the means used by those skilled in the data processing arts to most effectively convey the substance of their work to others skilled in the art. A procedure, logic block, process, etc., is here, and generally, conceived to be a self-consistent sequence of steps or instructions leading to a desired result. The steps are those requiring physical manipulations of physical quantities. Usually, though not necessarily, these quantities take the form of electrical or magnetic signals capable of being stored, transferred, combined, compared, and otherwise manipulated in a computer system. It has proven convenient at times, principally for reasons of

common usage, to refer to these signals as bits, bytes, values, elements, symbols, characters, terms, numbers, or the like.

It should be borne in mind, however, that all of these and similar terms are to be associated with the appropriate physical quantities and are merely convenient labels applied to these quantities. Unless specifically stated otherwise as apparent from the following discussions, it is appreciated that throughout the present invention, discussions utilizing terms such as "transmitting," "receiving," "using," "selecting," "implementing," "communicating," "identifying," "accessing," "arbitrating," "enforcing," "switching," "establishing," "executing," "maintaining," "interleaving," "enforcing" or the like, refer to the action and processes of a computer system or similar intelligent electronic computing device, that manipulates and transforms data represented as physical (electronic) quantities within the computer system's registers and memories into other data similarly represented as physical quantities within the computer system memories or registers or other such information storage, transmission or display devices.

The present invention is discussed primarily in a context in which devices and systems are coupled using wireless links, and specifically with regard to wireless links that use either the Bluetooth wireless technology or the IEEE 802.11b wireless technology. However, it is appreciated that the present invention may be utilized with devices and systems coupled using wireless technologies different from the Bluetooth and IEEE 802.11b technologies. In addition, it is appreciated that features of the present invention may be utilized with devices using more than two wireless technologies.

Figure 1A is a block diagram of one embodiment of a device 190 for hosting a Bluetooth transceiver 108 and a IEEE 802.11b transceiver 109 in accordance with the present invention. In the present embodiment, device 190 is any type of intelligent electronic device (e.g., a desktop, laptop or notebook computer system, a portable computer system, a personal digital assistant and the like). However, it is appreciated that aspects of the present invention may be implemented in other wireless communication devices such as cell phones, printers, fax machines, etc. It is also appreciated that aspects of the present invention may be implemented with other wireless technologies.

Device 190 includes an address/data bus 100 for communicating information, a central processor 150 coupled with the bus 100 for processing information and instructions, and a memory unit 110 (e.g., random access memory and/or read only memory) coupled with the bus 100 for storing information and instructions. It is appreciated that device 190 can include other elements not shown, or may not include all of the elements shown.

In the present embodiment, device 190 also optionally contains a display device 140 coupled to the bus 100 for displaying information to the user. The display device 140 utilized with device 190 may be a liquid crystal display (LCD) device, a cathode ray tube (CRT), a field emission display device (also called a flat panel CRT), or other display device suitable for generating graphic images and alphanumeric characters recognizable to the user.

Also included in device 190 is an optional alphanumeric input device 160. Alphanumeric input device 160 can communicate information and command selections to processor 150 via bus 100. In one implementation,

alphanumeric input device 160 is a keyboard. In another implementation, alphanumeric input device 160 is a handwriting recognition pad ("digitizer"). In yet another implementation, alphanumeric input device 160 is a touch screen device capable of registering a position where a stylus element (not shown) makes contact.

Device 190 also includes an optional cursor control or directing device (on-screen cursor control 180) coupled to bus 100 for communicating user input information and command selections to processor 150. In one implementation, on-screen cursor control 180 is a trackball, mouse, joystick or special keys on alphanumeric input device 160 capable of signaling movement of a given direction or manner of displacement. It is to be appreciated that the on-screen cursor control 180 also may be directed and/or activated via input from the keyboard using special keys and key sequence commands. In one implementation, on-screen cursor control device 180 is a touch screen device incorporated with display device 140 and capable of registering a position on display device 140 where a stylus element makes contact.

In one embodiment, in accordance with the present invention, device 190 includes a Bluetooth transmitter/receiver (transceiver or radio) 108, which is coupled to bus 100 and which provides a wireless radio (RF) communication link between device 190 and other wireless devices according to the Bluetooth specification. In this embodiment, device 190 also includes a IEEE 802.11b transceiver (radio) 109, which is coupled to bus 100 and which provides an RF communication link between device 190 and other wireless devices according to the IEEE 802.11b standard (also incorporated by reference in its entirety).

Thus, in the present embodiment, two separate personal computer (PC) cards (or circuit boards) are used, one (Bluetooth transceiver 108) to provide Bluetooth functionality and the other (IEEE 802.11b transceiver 109) to provide 802.11b functionality. It is appreciated that, in addition to PC card interfaces, Bluetooth transceiver 108 and 802.11b transceiver 109 can be implemented using a Universal Serial Bus (USB) interface, an internal USB interface, a CardBus interface, a Peripheral Component Interconnect (PCI) or mini-PCI interface, a Personal Computer Memory Card International Association (PCMCIA) interface, an Industry Standard Architecture (ISA) interface, or the like.

In one embodiment, device 190 of Figure 1A includes host interface circuitry 120 coupled to bus 100. Host interface circuitry 120 includes an optional digital signal processor (DSP) 122 for processing data to be transmitted or data that are received, in one embodiment, via Bluetooth transceiver 108 and/or IEEE 802.11b transceiver 109. Alternatively, processor 150 can perform some or all of the functions performed by DSP 122, in which case there may be no need for a second processor such as DSP 122.

Referring now to Figure 1B, in the present embodiment, to arbitrate between Bluetooth transceiver 108 and IEEE 802.11b transceiver 109, a software driver 111 resides in memory of device 190 (e.g., memory unit 110) and is executed by either processor 150 or DSP 122. Software driver 111 is aware of both Bluetooth transceiver 108 and IEEE 802.11b transceiver 109, makes decisions regarding which wireless technology is needed, and executes the instructions needed to implement that technology. In one embodiment, the arbitration logic software driver 111 of the present invention is situated between

each of Bluetooth transceiver 108 and 802.11b transceiver 109 and their respective drivers (112 and 113). As such, any communication between Bluetooth transceiver 108 and 802.11b transceiver 109 and their respective drivers 112 and 113 is intercepted by the arbitration logic software driver 111. Accordingly, the arbitration logic software driver 111 can implement its decisions regarding which of Bluetooth transceiver 108 and 802.11b transceiver 109 can be in use at a time. Additional information is provided in conjunction with Figure 4, below.

Figure 2A is a block diagram showing a second embodiment of a device 190 for hosting a Bluetooth transceiver and a IEEE 802.11b transceiver in accordance with the present invention. In this embodiment, the Bluetooth transceiver and the IEEE 802.11b transceiver are combined on a single card (or circuit board) 210 (e.g., a PC card interface, a USB interface, an internal USB interface, a CardBus interface, a PCI or mini-PCI interface, a PCMCIA interface, an ISA interface, or the like). In one embodiment, a single "mode agile" radio is used; that is, the radio can serve as either an 802.11b transceiver or as a Bluetooth transceiver, depending on the mode of operation selected by the arbitration logic. Also in this embodiment, with reference to Figure 2B, the driver 111 for arbitrating between Bluetooth and 802.11b is located in memory unit 110, although interfacing aspects of the driver may also reside on card 210.

Figure 3A is a block diagram showing a third embodiment of a device 190 for hosting a Bluetooth transceiver and a IEEE 802.11b transceiver in accordance with the present invention. In this embodiment, the Bluetooth transceiver and the IEEE 802.11b transceiver are combined on a single card (or circuit board) 310 (e.g., a PC card interface, a USB interface, an internal USB

interface, a CardBus interface, a PCI or mini-PCI interface, a PCMCIA interface, an ISA interface, or the like). As in the above, a single radio that can serve as either an 802.11b transceiver or as a Bluetooth transceiver can be used.

In this embodiment, with reference to Figure 3B, the driver 311 for arbitrating between Bluetooth and 802.11b radios 312 is located on the Bluetooth and 802.11b transceiver card 310. In one embodiment, driver 311 is implemented in hardware on card 310 using an application specific integrated circuit (ASIC) or some other type of microprocessor.

Figure 4 is a flowchart of the steps in a process 400 for arbitrating between different wireless technologies in accordance with one embodiment of the present invention. As described above, in various embodiments, process 400 is implemented by device 190 as computer-readable program instructions (driver 111 of Figures 1B and 2B) stored in a memory unit 110 (Figures 1A and 2A) and executed by a processor (e.g., processor 150 or DSP 122 of Figures 1A and 2A). In one embodiment, process 400 is implemented as computer-readable program instructions (arbitration logic 311 of Figure 3B) stored on and executed by a card 310 coupled with device 190 (Figure 3A). In one such embodiment, driver 311 is implemented as computer-readable program instructions implemented in hardware using an ASIC or some other type of microprocessor. Process 400 is described for an embodiment using the Bluetooth and 802.11b technologies; however, it is appreciated that process 400 may be utilized with other wireless technologies.

In step 410 of Figure 4, in one embodiment, device 190 is operable in both the Bluetooth mode and in the 802.11b mode. However, in the

embodiment of Figure 1A, in which there is both a Bluetooth transceiver 108 and an 802.11b transceiver 109, while one of the radios is transmitting, the other radio cannot be receiving and vice versa, although both may be either transmitting or receiving at the same time. In the embodiments of Figures 2A and 3A, in which there may be a single multi-modal transceiver operable as either a Bluetooth transceiver or as a 802.11b transceiver (e.g., Bluetooth and IEEE 802.11b transceiver 210 and 310, respectively), the transceiver can be switched from one wireless mode to another.

Bluetooth connections between device 190 and other devices are typically transactional in nature; that is, Bluetooth connections are generally ad hoc connections made to a peripheral device only for the length of time needed to accomplish a specific, perhaps time-limited task. Once the task is completed, the connection is broken. On the other hand, 802.11b connections are generally more persistent, providing relatively constant connections between devices in order to provide the functionality of a wireless local area network (WLAN). Accordingly, in one embodiment, in step 410, device 190 is operating in the 802.11b mode as a default mode; however, it is appreciated that the present invention can also be implemented with Bluetooth as the default mode. Alternatively, device 190 can be implemented without a default mode (that is, with device 190 in neither the Bluetooth mode nor the 802.11b mode, until one of the modes is needed).

In step 420 of Figure 4, in one embodiment, with device 190 operable in one mode (e.g., either the Bluetooth mode, 802.11b mode, or neither of these modes), a need for operation in the other mode is identified. For example, with

device 190 coupled to a WLAN via an 802.11b connection, there is a need to establish a Bluetooth connection to a printer.

In step 430 of Figure 4, according to the various embodiments of the present invention, driver 111 (Figures 1B and 2B) or arbitration logic 311 (Figure 3B) arbitrate between 802.11b and Bluetooth; that is, depending on the services required, driver 111 or arbitration logic 311 can select and implement either 802.11b or Bluetooth. In one embodiment, the 802.11b and Bluetooth radio (RF) traffic is controlled on a packet-by-packet basis, in which data packets or groups of data packets are transmitted and/or received in small "bursts." In another embodiment, the 802.11b and Bluetooth radio traffic is interleaved using time-domain division (TDD). For example, a portion of the 802.11b traffic is transmitted for a certain period of time, halted, and then started again, and the Bluetooth traffic is transmitted for the period of time during which the 802.11b traffic was halted. To the user, in either of these embodiments, each of the wireless systems appears to be active at the same time.

In another embodiment, one of the wireless systems can be made available to send and/or receive, while the other is made unavailable; in essence, the arbitration logic serves to toggle between the two systems, depending on which one might be needed. In one embodiment, the 802.11b connection (e.g., to a WLAN) is not turned off; a persistent 802.11b connection to the WLAN is maintained even while a Bluetooth connection is being made or is available.

In another embodiment, the RF traffic is interleaved in the frequency domain, wherein the wireless systems operate simultaneously but are

separated in frequency within the same band or channel. In this embodiment, for example, the Bluetooth radio performs frequency hopping using a smaller channel set, and does not hop onto a frequency that is occupied by an 802.11b connection.

In step 440, the wireless mode selected by the arbitration logic is implemented. As described above, in various embodiments, the arbitration logic can control the mode of operation on a packet-by-packet basis, by interleaving traffic in the frequency domain, by toggling between the different wireless technologies, or by using TDD. In the latter case, the amount of time that device 190 is operable in one mode or the other is determined based on a number of factors.

In one embodiment, the arbitration logic enforces a time period that allows device 190 to transmit/receive in one mode for a time period long enough to allow data to be transmitted/received efficiently between devices and transparently to the user (that is, without a noticeable or significant degradation in performance). On the other hand, the arbitration logic also enforces a time period that is short enough so that, while data are being transmitted/received according to one mode, a timeout does not occur in the other mode. For example, when device 190 receives a Bluetooth packet from another device that requires a response, if the expected response is not received within a certain period of time, a timeout condition can occur. Consequently, the arbitration logic allows device 190 to transmit/receive in the 802.11b mode only within the time constraint defined for the timeout condition. It is appreciated that, alternatively, the time period defined for the timeout condition can be lengthened, or that other measures can be taken to prevent a timeout from

occurring in an environment (network) in which Bluetooth and 802.11b need to coexist.

It is also appreciated that, in one embodiment, the arbitration logic also enforces time periods during which device 190 can receive broadcast messages that are initiated by other devices. That is, the arbitration logic enforces periods of time during which device 190 is in a listen mode, receptive to messages initiated by other wireless devices (such as the page or scan messages used by Bluetooth devices).

The preferred embodiment of the present invention is thus described. While the present invention has been described in particular embodiments, it should be appreciated that the present invention should not be construed as limited by such embodiments, but rather construed according to the following claims.

All of the numerical and quantitative measurements set forth in this application (including in the examples and in the claims) are approximations.

The invention illustratively disclosed or claimed herein suitably may be practiced in the absence of any element which is not specifically disclosed or claimed herein. Thus, the invention may comprise, consist of, or consist essentially of the elements disclosed or claimed herein.

The following claims are entitled to the broadest possible scope consistent with this application. The claims shall not necessarily be limited to the preferred embodiments or to the embodiments shown in the examples.

## CLAIMS

What is claimed is:

1. A method for combining different wireless technologies in a single device, said method comprising:

executing an arbitration logic for implementing a communication scheme comprising a first mode and a second mode, wherein said first mode corresponds to a first wireless technology and second mode corresponds to a second wireless technology; and

communicating first traffic using said first wireless technology and second traffic using said second wireless technology by selectively implementing said first mode and said second mode according to said arbitration logic.

2. An apparatus combining different wireless technologies, said apparatus comprising:

a processor;

a first wireless transceiver coupled to said processor, said first wireless transceiver adapted to communicate according to a first wireless technology; and

a second wireless transceiver coupled to said processor, said second wireless transceiver adapted to communicate according to a second wireless technology;

wherein said apparatus implements a method for combining different wireless technologies, said method comprising the method of claim 1.

3. A computer usable medium having computer readable code stored thereon for causing a computer system to perform a method for combining different wireless technologies in a single device, said method comprising the method of claim 1.

4. The method of Claim 1 wherein said wireless technologies are selected from the group consisting of Bluetooth and IEEE 802.11b.

5. The method of Claim 4 comprising:

maintaining a persistent IEEE 802.11b connection to a first wireless device during a Bluetooth connection with a second wireless device.

6. The apparatus of Claim 2 wherein said wireless technologies are selected from the group consisting of Bluetooth and IEEE 802.11b.

7. The apparatus of Claim 6 wherein said method comprises:

maintaining a persistent IEEE 802.11b connection to a first wireless device during a Bluetooth connection with a second wireless device.

8. The computer usable medium of Claim 3 wherein said wireless technologies are selected from the group consisting of Bluetooth and IEEE 802.11b.

9. The method of Claims 1, 2, or 3 comprising:

implementing a default mode when communication according to a mode other than said default mode is completed, said default mode selected from said first and second modes.

10. The method of Claim 9 wherein said default mode corresponds to IEEE 802.11b.

11. The method of Claim 1, the apparatus of Claim 2 or the computer usable medium of Claim 3, wherein said arbitration logic comprises:

interleaving said first traffic and said second traffic, said interleaving accomplished using time-domain division.

12. The method of Claim 1, the apparatus of Claim 2 or the computer usable medium of Claim 3, wherein said arbitration logic comprises:

alternating between implementing said first mode and implementing said second mode.

13. The method of Claim 1, the apparatus of Claim 2 or the computer usable medium of Claim 3, wherein said arbitration logic comprises:

communicating using two wireless technologies at the same time, wherein traffic communicated using one of said wireless technologies is at a first frequency and traffic communicated using another of said wireless technologies is at a different frequency.

14. The method of Claim 1, the apparatus of Claim 2 or the computer usable medium of Claim 3, wherein said arbitration logic comprises:

enforcing a time period during which communication using one of said wireless technologies can occur, wherein upon expiration of said time period a mode corresponding to another of said wireless technologies is selected and implemented.

15. The apparatus of Claim 2, wherein said first and second wireless transceivers are implemented as a single device.

16. The apparatus of Claim 15 wherein said single device comprises a single radio adapted to communicate using either of said first and second wireless technologies.

17. The apparatus of Claim 2 comprising:

a microprocessor coupled to said first wireless transceiver and said second wireless transceiver, said microprocessor for implementing said method.

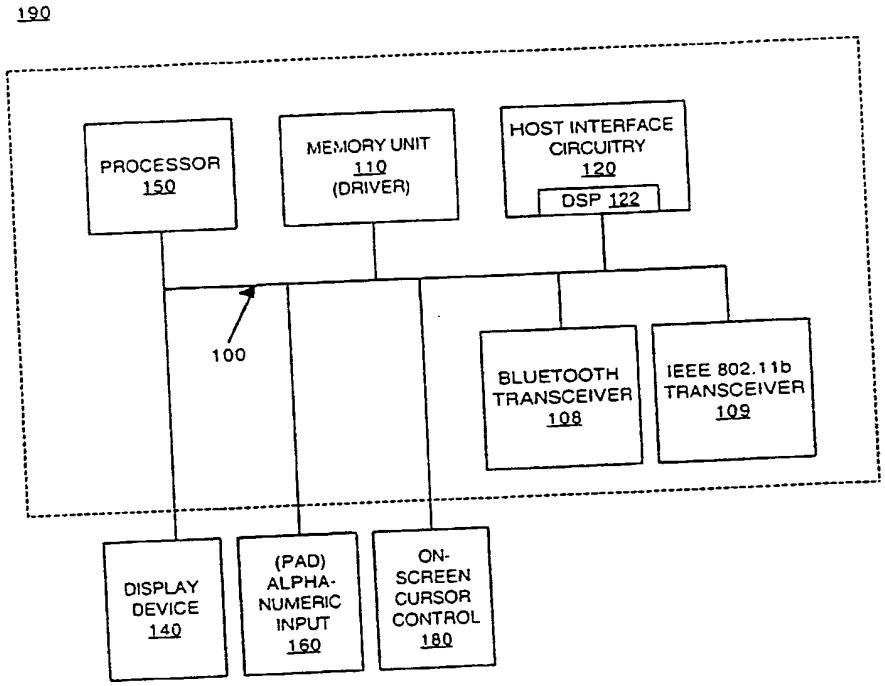
190
PROCESSOR
150
MEMORY UNIT
110
(DRIVER)
HOST INTERFACE
CIRCUITRY
120
DSP 122
100
BLUETOOTH
TRANSCEIVER
108
IEEE 802.11b
TRANSCEIVER
109
DISPLAY
DEVICE
140
(PAD)
ALPHA-
NUMERIC
INPUT
160
ON-
SCREEN
CURSOR
CONTROL
180

Figure 1A

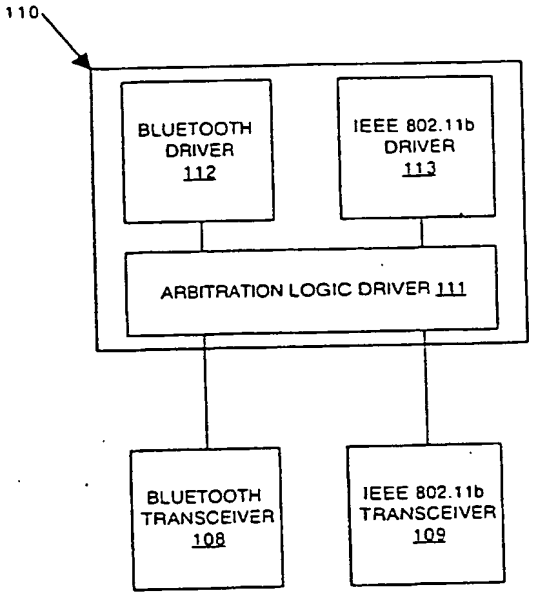
110
BLUETOOTH DRIVER 112
IEEE 802.11b DRIVER 113
ARBITRATION LOGIC DRIVER 111
BLUETOOTH TRANSCEIVER 108
IEEE 802.11b TRANSCEIVER 109

Figure 1B

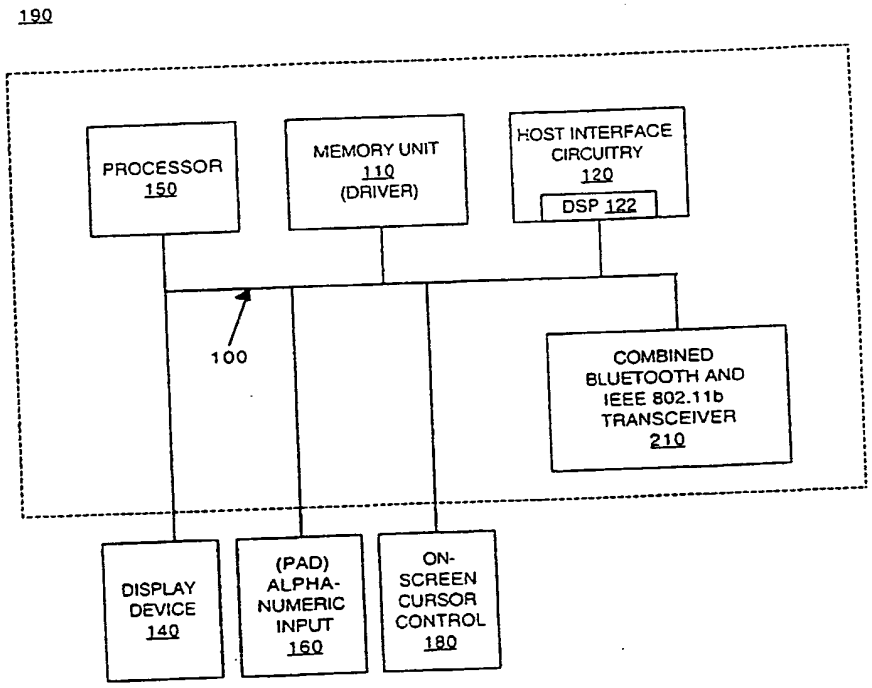
190
PROCESSOR
150
MEMORY UNIT
110
(DRIVER)
HOST INTERFACE
CIRCUITRY
120
DSP 122
100
COMBINED
BLUETOOTH AND
IEEE 802.11b
TRANSCEIVER
210
DISPLAY
DEVICE
140
(PAD)
ALPHA-
NUMERIC
INPUT
160
ON-
SCREEN
CURSOR
CONTROL
180

Figure 2A

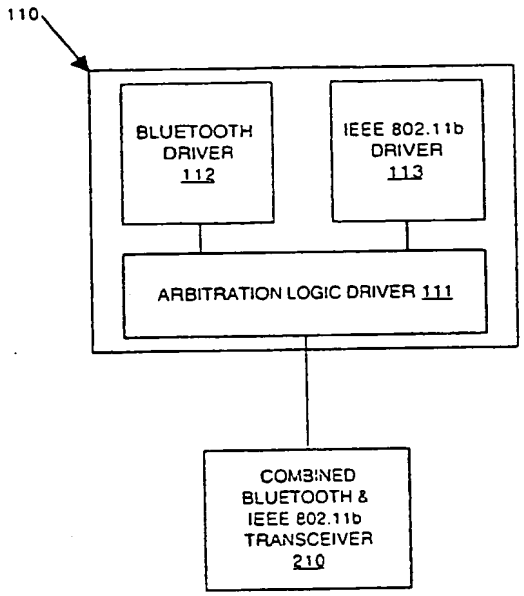
110
BLUETOOTH DRIVER 112
IEEE 802.11b DRIVER 113
ARBITRATION LOGIC DRIVER 111
COMBINED BLUETOOTH & IEEE 802.11b TRANSCEIVER 210

Figure 2B

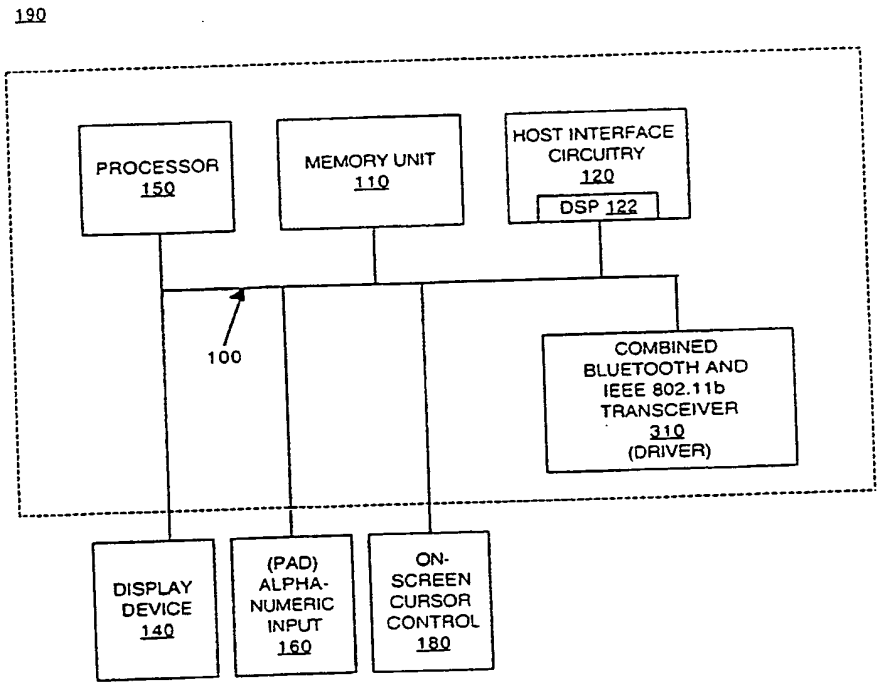
190
PROCESSOR
150
MEMORY UNIT
110
HOST INTERFACE
CIRCUITRY
120
DSP 122
100
COMBINED
BLUETOOTH AND
IEEE 802.11b
TRANSCEIVER
310
(DRIVER)
DISPLAY
DEVICE
140
(PAD)
ALPHA-
NUMERIC
INPUT
160
ON-
SCREEN
CURSOR
CONTROL
180

Figure 3A

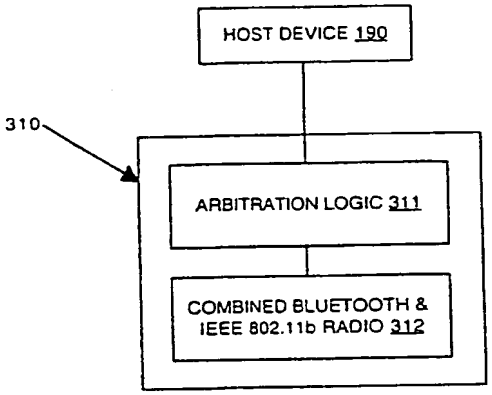
HOST DEVICE 190
310
ARBITRATION LOGIC 311
COMBINED BLUETOOTH & IEEE 802.11b RADIO 312

Figure 3B

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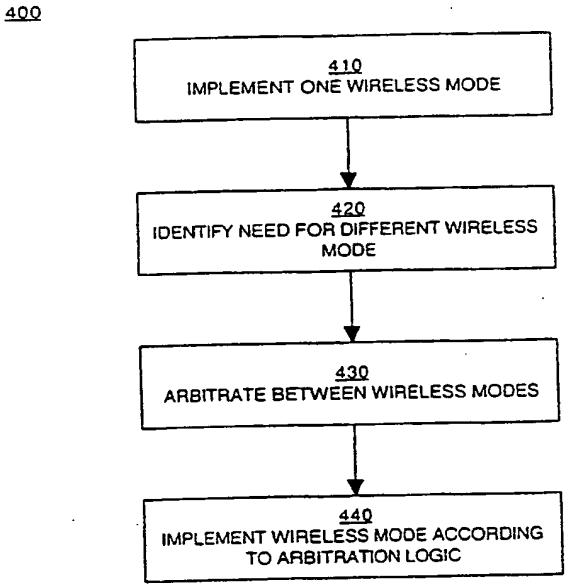


Figure 4